# PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

## PCT

### NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

| | |
|---|---|
| **Date of mailing** (day/month/year)<br>17 December 1999 (17.12.99) | |
| **International application No.**<br>PCT/FI99/00277 | **Applicant's or agent's file reference**<br>2980116PC/TA |
| **International filing date** (day/month/year)<br>01 April 1999 (01.04.99) | **Priority date** (day/month/year)<br>07 April 1998 (07.04.98) |
| **Applicant**<br>KIRJAVAINEN, Kari | |

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:

   01 November 1999 (01.11.99)

   [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

   [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

| | |
|---|---|
| **The International Bureau of WIPO**<br>**34, chemin des Colombettes**<br>**1211 Geneva 20, Switzerland** | Authorized officer<br>S. De Michiel |
| Facsimile No.: (41-22) 740.14.35 | Telephone No.: (41-22) 338.83.38 |

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| Applicant's or agent's file reference<br>2980116PC/TA | **FOR FURTHER ACTION** - See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) | |
|---|---|---|
| International application No.<br>PCT/FI99/00277 | International filing date *(day/month/year)*<br>01.04.1999 | Priority date *(day/month/year)*<br>07.04.1998 |
| International Patent Classification (IPC) or national classification and IPC7<br>B29C 55/02, B29C 55/14 | | |
| Applicant<br>NATURAL COLOUR KARI KIRJAVAINEN OY et al | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

| Date of submission of the demand | Date of completion of this report |
|---|---|
| 01.11.1999 | 24.05.2000 |
| Name and mailing address of the IPEA/SE<br>Patent- och registreringsverket<br>Box 5055<br>S-102 42 STOCKHOLM<br>Facsimile No. 08-667 72 88<br>Telex<br>17978<br>PATOREG-S | Authorized officer<br>Maria Börlin/MP<br>Telephone No. 08-782 25 00 |

Form PCT/IPEA/409 (cover sheet) (January 1994)

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/FI99/00277

## I. Basis of the report

1. This report has been drawn on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

☒ the international application as originally filed.

☐ the description, pages _____, as originally filed,
pages _____, filed with the demand,
pages _____, filed with the letter of _____,
pages _____, filed with the letter of _____.

☐ the claims, Nos. _____, as originally filed,
Nos. _____, as amended under Article 19,
Nos. _____, filed with the demand,
Nos. _____, filed with the letter of _____,
Nos. _____, filed with the letter of _____.

☐ the drawings, ~~sheets~~/fig _____, as originally filed,
~~sheets~~/fig _____, filed with the demand
~~sheets~~/fig _____, filed with the letter of _____,
~~sheets~~/fig _____, filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, ~~sheets~~/fig _____

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/FI99/00277

**V. Resoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Claims | 1-17 | YES |
| | Claims | | NO |
| Inventive step (IS) | Claims | 1-17 | YES |
| | Claims | | NO |
| Industrial applicability (IA) | Claims | 1-17 | YES |
| | Claims | | NO |

2. Citations and explanations

The invention according to clams 1 and 6 relates to a method and apparatus for producing a stretched plastic film containing gas filled cavitation bubbles. The bubbles are obtained by mixing a material into the plastic before extrusion, stretching the extruded plastic film simultaneously as a pressurized gas acts on the film. The invention according to claim 14 relates to a film produced by the method of claim 1.

Document US 5188777 A discloses a stretched plastic film contining voids. This known film differs from the one produced according to the present application in that the film has not been exposed to a pressurized gas in order to obtain gas filled voids. It is not considered obvious to a person skilled in the art to expose the film disclosed in US 5188777 A to pressurized gas in order to obtain gas filled voids. The invention according to claims 1-17 is thus novel and is considered to involve an inventive step.

Documents DE 3513516 A1 and GB 1384556 A also disclose methods for producing void containing films, but are considered to be of less relevance.

WO 99/51419
PCT/FI99/00277

# PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

## PCT

**NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES**

(PCT Rule 47.1(c), first sentence)

To:
KOLSTER OY AB
Iso Roobertinkatu 23
P.O. Box 148
FIN-00121 Helsinki
FINLANDE

| | |
|---|---|
| **Date of mailing** (day/month/year)<br>14 October 1999 (14.10.99) | |
| **Applicant's or agent's file reference**<br>2980116PC/TA | **IMPORTANT NOTICE** |
| **International application No.**<br>PCT/FI99/00277 | **International filing date** (day/month/year)<br>01 April 1999 (01.04.99) |
| **Priority date** (day/month/year)<br>07 April 1998 (07.04.98) | |
| **Applicant**<br>NATURAL COLOUR KARI KIRJAVAINEN OY et al | |

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,CN,EP,IL,JP,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CU,CZ,DE,DK,EA,EE,ES,FI,GB,GD,GE,GH,GM,HR,
   HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,
   SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZA,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   14 October 1999 (14.10.99) under No. WO 99/51419

### REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, **a demand for international preliminary examination** must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

### REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the **national phase**, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

**The International Bureau of WIPO**
**34, chemin des Colombettes**
**1211 Geneva 20, Switzerland**

Facsimile No. (41-22) 740.14.35

Authorized officer
J. Zahra

Telephone No. (41-22) 338.83.38

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference 2980116PC/TA | FOR FURTHER ACTION | see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below. |
|---|---|---|
| International application No. PCT/FI 99/00277 | International filing date *(day/month/year)* 1 April 1999 | (Earliest) Priority Date *(day/month/year)* 7 April 1998 |
| Applicant Natural Colour Kari Kirjavainen Oy et al | | |

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (See Box I).

2. [ ] **Unity of invention is lacking** (See Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the title,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the abstract,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is:

   Figure No. 7
   - [ ] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [X] because this figure better characterizes the invention.
   - [ ] None of the figures.

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00277

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B29C 55/02, B29C 55/14
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 5188777 A (BURDETTE L. JOESTEN ET AL), 23 February 1993 (23.02.93), column 4, line 3 - line 14<br>-- | 1-17 |
| A | DE 3513526 A1 (HOECHST AG), 16 October 1986 (16.10.86), page 6, line 20 - line 24; page 7, line 19 - page 8, line 9<br>-- | 1-17 |
| A | GB 1384556 A (MITSUBISHI PETROCHEMICAL COMPANY LIMITED), 19 February 1975 (19.02.75), page 2, line 63 - line 90; page 4, line 25 - line 41, figures 2-4<br>-- | 1-17 |

---

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 9 August 1999 | 11 -08- 1999 |
| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Authorized officer<br>Maria Börlin/ELY<br>Telephone No. +46 8 782 25 00 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

01/07/99

International application No.
PCT/FI 99/00277

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 5188777 A | 23/02/93 | US 5134173 A | 28/07/92 |
| DE 3513526 A1 | 16/10/86 | NONE | |
| GB 1384556 A | 19/02/75 | NONE | |

**PCT** WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
B29C 55/02, 55/14

A1

(11) International Publication Number: **WO 99/51419**

(43) International Publication Date: 14 October 1999 (14.10.99)

(21) International Application Number: PCT/FI99/00277

(22) International Filing Date: 1 April 1999 (01.04.99)

(30) Priority Data:
980800 7 April 1998 (07.04.98) FI

(71) Applicant *(for all designated States except US)*: NATURAL COLOUR KARI KIRJAVAINEN OY [FI/FI]; Palomäentie 14 B 13, FIN–33230 Tampere (FI).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: KIRJAVAINEN, Kari [FI/FI]; Kivenlahdentie 11 A 4, FIN–02320 Espoo (FI).

(74) Agent: KOLSTER OY AB; Iso Roobertinkatu 23, P.O. Box 148, FIN–00121 Helsinki (FI).

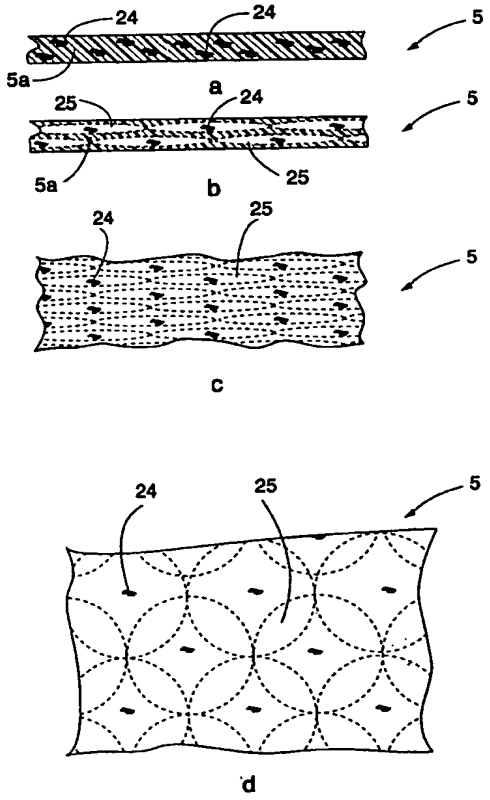
(81) Designated States: AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published**
*With international search report.*
*Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.*

(54) Title: METHOD AND APPARATUS FOR MAKING PLASTIC FILM, AND PLASTIC FILM

(57) Abstract

A film (5) is extruded from plastic material (5a) by an extruder (1). The film is orientated after extrusion. Material is mixed into the plastic (5a) so that when the plastic film (5) is stretched, cavitation bubbles are formed in the material particles mixed into the plastic (5a). During the orientation, gas is arranged to act on the plastic film under high pressure so that the gas diffuses in the cavitation bubbles and causes overpressure in them. Thus it is possible to make a thin foamed film with a foaming degree over 70 %.



*FOR THE PURPOSES OF INFORMATION ONLY*

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **AL** | Albania | **ES** | Spain | **LS** | Lesotho | **SI** | Slovenia |
| **AM** | Armenia | **FI** | Finland | **LT** | Lithuania | **SK** | Slovakia |
| **AT** | Austria | **FR** | France | **LU** | Luxembourg | **SN** | Senegal |
| **AU** | Australia | **GA** | Gabon | **LV** | Latvia | **SZ** | Swaziland |
| **AZ** | Azerbaijan | **GB** | United Kingdom | **MC** | Monaco | **TD** | Chad |
| **BA** | Bosnia and Herzegovina | **GE** | Georgia | **MD** | Republic of Moldova | **TG** | Togo |
| **BB** | Barbados | **GH** | Ghana | **MG** | Madagascar | **TJ** | Tajikistan |
| **BE** | Belgium | **GN** | Guinea | **MK** | The former Yugoslav Republic of Macedonia | **TM** | Turkmenistan |
| **BF** | Burkina Faso | **GR** | Greece | | | **TR** | Turkey |
| **BG** | Bulgaria | **HU** | Hungary | **ML** | Mali | **TT** | Trinidad and Tobago |
| **BJ** | Benin | **IE** | Ireland | **MN** | Mongolia | **UA** | Ukraine |
| **BR** | Brazil | **IL** | Israel | **MR** | Mauritania | **UG** | Uganda |
| **BY** | Belarus | **IS** | Iceland | **MW** | Malawi | **US** | United States of America |
| **CA** | Canada | **IT** | Italy | **MX** | Mexico | **UZ** | Uzbekistan |
| **CF** | Central African Republic | **JP** | Japan | **NE** | Niger | **VN** | Viet Nam |
| **CG** | Congo | **KE** | Kenya | **NL** | Netherlands | **YU** | Yugoslavia |
| **CH** | Switzerland | **KG** | Kyrgyzstan | **NO** | Norway | **ZW** | Zimbabwe |
| **CI** | Côte d'Ivoire | **KP** | Democratic People's Republic of Korea | **NZ** | New Zealand | | |
| **CM** | Cameroon | | | **PL** | Poland | | |
| **CN** | China | **KR** | Republic of Korea | **PT** | Portugal | | |
| **CU** | Cuba | **KZ** | Kazakstan | **RO** | Romania | | |
| **CZ** | Czech Republic | **LC** | Saint Lucia | **RU** | Russian Federation | | |
| **DE** | Germany | **LI** | Liechtenstein | **SD** | Sudan | | |
| **DK** | Denmark | **LK** | Sri Lanka | **SE** | Sweden | | |
| **EE** | Estonia | **LR** | Liberia | **SG** | Singapore | | |

# METHOD AND APPARATUS FOR MAKING PLASTIC FILM, AND PLASTIC FILM

The invention relates to a method for making a plastic film, the method comprising extruding a plastic film and orientating it.

The invention also relates to an apparatus for making a plastic film, the apparatus comprising an extruder and at least one orientation device for orientating the extruded film.

The invention further relates to a plastic film which comprises bubbles with the maximum diameter of about 100 micrometers and the maximum height of about 10 micrometers.

Making a plastic film by extruding it and then orientating it is known e.g. from US patents 3,244,781 and 3,891,374. It is, however, difficult to make thin and in particular thin foamed films using these solutions.

EP publication 0,182,764 discloses a thin polypropylene film which contains wide and flat disk-like bubbles, which are about 80 micrometers in length and about 50 micrometers in width. The film is produced by extruding material which has been foamed chemically or by means of gas and by orientating the extruded material biaxially. The result is a very versatile plastic film. However, the foaming degree of the film is less than 50%, which is why the properties of the film are not good enough for all purposes.

Furthermore, it is not possible to produce thin films of polymethylpentene or cyclic olefin copolymer using the prior art solutions.

The object of this invention is to provide a very good and thin foamed plastic film and a simple and reliable method and apparatus for making said plastic film.

The method of the invention is characterized in that before extrusion material is mixed into the plastic of the plastic film, cavitation bubbles are formed in the plastic film to be stretched due to the influence of the material, after extrusion the plastic film is orientated by stretching, and simultaneously with orientation pressurized gas is arranged to act on the plastic film so that the gas diffuses in the cavitation bubbles, and thus bubbles containing gas are formed in the plastic film.

The apparatus of the invention is characterized in that the apparatus comprises gas supply means arranged in one orientation device for feeding pressurized gas into the plastic film simultaneously with orientation by stretching so that the fed gas diffuses in the cavitation bubbles that are formed

in the plastic film during stretching, and thus bubbles containing gas are formed in the plastic film.

The plastic film of the invention is characterized in that material is mixed into the plastic of the plastic film, cavitation bubbles are formed in the plastic film to be stretched due to the influence of the material, and the plastic film is subjected to stretching and to pressure of pressurized gas simultaneously with stretching so that the bubbles contain said gas, the foaming degree of the plastic film being over 70%.

The basic idea of the invention is that a film is extruded from plastic material by means of an extruder and material has been mixed into the plastic so that when the plastic is stretched, cavitation bubbles are formed in the material particles mixed into the plastic. The film is orientated by stretching and at the same time gas is fed into the film under high pressure so that the gas diffuses in the cavitation bubbles and causes overpressure in them. The idea of a preferred embodiment is that after the first orientation the plastic film is orientated by stretching it in the direction substantially perpendicular to the first orientation direction, and thus the overpressure is released in the cavitation bubbles and the bubbles expand.

An advantage of the invention is that very thin films with a foaming degree of about 70 to 90% can be provided in a relatively simple manner. An advantage of the high foaming degree is that the electric and mechanical properties of the film are very good. A further advantage is that the method and apparatus can be used for making a film for example of polymethylpentene or cyclic olefin copolymer.

The invention will be described in greater detail in the following drawings, in which

Figure 1 is a schematic cross-sectional side view of an apparatus of the invention,

Figure 2 is a partially cross-sectional top view of the apparatus illustrated in Figure 1,

Figure 3 is a cross-sectional view of a detail of the apparatus illustrated in Figure 1 along line A-A,

Figure 4 is a cross-sectional view of a detail of the apparatus illustrated in Figure 1 along line B-B,

Figure 5 is a cross-sectional view of a detail of the apparatus illustrated in Figure 1 along line C-C,

Figure 6 is a schematic cross-sectional top view of an extruder used in the apparatus of the invention,

Figure 7a is a cross-sectional side view of a plastic film extruded by the apparatus of the invention before orientation of the film,

Figure 7b is a cross-sectional side view of the plastic film extruded by the apparatus of the invention after longitudinal orientation,

Figure 7c is a schematic top view of the plastic film illustrated in Figure 7b, and

Figure 7d is a schematic top view of the plastic film made by the apparatus of the invention after longitudinal and cross-direction orientations.

Figure 1 is a side view of an apparatus according to the invention. The apparatus comprises an extruder 1. The extruder may be for example conical, i.e. it comprises a cone-shaped rotor 2, outside of which there is an outer stator 3 whose surface at least on the rotor 2 side is cone-shaped, and inside the rotor there is an inner stator 4 whose surface at least on the rotor 2 side is cone-shaped. When the rotor 2 rotates, it extrudes material which is between the rotor 2 and the stators 3 and 4 from the extruder 1 in a manner known per se. For the sake of clarity the figures do not illustrate e.g. the rotating means of the rotor or the feeding devices for feeding the material to be extruded into the extruder 1. The extruder 1 may comprise more than one rotor 2 and more than two stators 3 and 4. In that case the extruder 1 can be used for extruding multilayer products. The solution with one rotor 2 and two stators 3 and 4 can be used for making two-layer products. The end portion of the inner stator 4 is wide and tapers in the vertical direction so that together with the nozzle 6 it forms a relatively flat and wide gap through which the plastic 5a is extruded. After the nozzle 6 there is a calibration piece 7 whose nuts are used for adjusting the height of the gap, which allows to define the thickness of the plastic film 5 to be obtained from the extruder 1.

After the extruder 1 the plastic film 5 is cooled by a cooling device 8. The cooling device 8 may comprise e.g. a cooling roll 9, which is arranged in a cooling tank 10 containing a cooling medium, e.g. water. The plastic film 5 is arranged to be pressed against the cooling roll 9. The apparatus according to Figure 1 uses auxiliary rolls 11 for guiding the plastic film 5 at several points.

After cooling the plastic film 5 is guided to a machine direction orientation device 12. The machine direction orientation device 12 comprises orientation rolls 13 whose velocities are adjusted so that they can be used for

stretching the plastic film 5 and thus for orientation in the machine direction. If desired, the velocity of each orientation roll 13 can be adjusted separately. The machine direction orientation device 12 may also comprise heating means 14, such as radiation heaters, for heating the plastic film 5 in a manner known per se. The orientation rolls 13 can also be used for heating the plastic film by supplying a heating medium, such as heated oil, to the orientation rolls 13 so that the orientation rolls 13 become warm. If desired, the temperature of each orientation roll 13 can be adjusted separately.

The orientation rolls are arranged in a discharge chamber 15. Pressurized gas, preferably air, is fed into the discharge chamber 15 along a gas supply pipe 16. Instead of air, nitrogen or another gas or gas mixture, for instance, may be used as the gas to be fed. The gas to be fed may also be selected according to the desired electric properties. For example, in respect of the dielectric strength of the product it would be advisable to use sulphurhexafluoride $SF_6$ and in respect of chargeability e.g. argon. The pressure of the gas to be fed is relatively small compared to the typical foaming methods, being preferably about 10 bars, but it may vary between 3 and 20 bars, for instance. Suitable material, such as calcium carbonate particles, is mixed into the plastic 5a of the plastic film 5, and due to the influence of the particles the joint surfaces of the plastic molecules and the mixed material are torn during orientation, and thus cavitation bubbles are formed. When orientation is performed by arranging pressurized gas to act on the plastic film 5, the gas in question diffuses in the cavitation bubbles and causes overpressure in the bubbles. In the discharge chamber 15 the pressurized gas can act on both sides of the plastic film 5, and thus gas bubbles are formed evenly in the plastic film 5. The discharge chamber 15 is sealed at the entry and exit of the plastic film 5 in a manner known per se.

After the machine direction orientation device 12 the plastic film 5 is supplied to a cross-direction orientation device 17. In the cross-direction orientation device 17 the plastic film 5 is stretched in the cross-direction, i.e. orientation is performed in the direction substantially perpendicular to the direction of the orientation performed in the machine direction device 12. Due to the overpressure of the gas in the bubbles and cross-direction stretching the bubbles can grow sideways and also to some extent in the vertical direction in the cross-direction orientation device 17. In that case the foaming degree of the film is for example about 70 to 90%. The foaming degree can be adjusted

simply by adjusting the pressure of the gas to be fed into the discharge chamber 15. The cross-direction orientation device 17 comprises two orientation wheels 18, and an orientation band 19 is arranged against both of the wheels. The orientation band 19 is an endless band which is guided by means of band guide rolls 20. The orientation band 19 presses the edges of the plastic film 5 firmly and evenly between the orientation wheel 18 and the orientation band 19 substantially along the whole travel the cross-direction orientation device 17, in which case the film is not subjected to varying pressure stress or tensile strain, and thus the plastic film stretches sideways without tearing. In Figure 1 the plastic film 5, orientation wheel 18 and orientation band 19 are illustrated at a distance from one another for the sake of clarity, but in reality these parts are pressed firmly against one another. The orientation wheels 18 and the orientation bands 19 are arranged so that in the direction of the plastic film they are further away from one another at the end than at the beginning, as is illustrated in Figure 2, and thus the cross-direction orientation device 17 stretches and simultaneously orientates the plastic film 5 in the cross-direction. The deviation of the angle between the orientation wheels 18 and the orientation bands 19 from the machine direction can be adjusted according to the desired degree of cross-direction stretching. One or more band guide rolls 20 can be arranged to be rotated by the rotating means. Since the bands 19 are firmly pressed against the orientation wheels 18, the orientation wheels 18 do not necessarily need rotating means but may rotate freely. For the sake of clarity the enclosed figures do not illustrate rotating means or other actuators of the apparatus. A curved support plate 21, which has substantially the same shape as the circumference of the orientation wheels 18, is arranged between the orientation wheels 18 to support the plastic film 5.

The cross-direction orientation device 17 can be placed in a casing 26 of its own. If desired, the casing 26 can be provided with heaters known per se, such as radiation heaters, to heat the plastic film 5.

After the cross-direction orientation device 17 the plastic film 5 is led to a relaxation unit 22. In the relaxation unit 22 the plastic film 5 is relaxed, and thus the plastic film shrinks a bit in a manner known per se. Finally, the plastic film 5 is wound on a reel 23.

Figure 2 is a cross-sectional top view of the apparatus of the invention at the extruder 1. For the sake of clarity Figure 2 does not illustrate

the plastic film 5 or the support structures of the apparatus onto which the rolls, reels and plates of the apparatus are attached, for instance.

Figure 3 is a cross-sectional view of a detail of the extruder 1 along line A-A of Figure 1. Here both the outer stator and the inner stator 4 are round in cross-section. Thus the plastic material 5a is also in an annular feeding channel.

Figure 4 is a cross-sectional view of a detail of the extruder 1 along line B-B of Figure 1. Here we see the wide tip of the inner stator 4 and the shape of the nozzle 6 which extrude the plastic 5a into the wide and flat gap, and thus a flat plastic film 5 is formed from the plastic 5a.

Figure 5 is a cross-sectional view of a detail of the cross-direction orientation device 17 along line C-C of Figure 1. It is seen in Figure 5 how the orientation wheel and the orientation band are pushed against each other and press the plastic film 5 between each other. The surface of the support plate 21 against the plastic film 5 may be heated e.g. by providing it with heating resistors, and thus the plastic film 5 slides along the sliding surface in question very easily. Furthermore, propellant, such as air, can be blown from the support plate 21 through the gaps 21a, in which case the propellant flowing through the gaps 21a provides a sliding bearing between the support plate 21 and the plastic film 5. The gas in question may be heated, if desired, and thus the sliding surface of the support plate 21 and the plastic film 5 are heated with the propellant flowing through the gaps 21a.

Figure 6 illustrates an extruder 1 used in the apparatus according to the invention. The nozzle 6 of the extruder 1 widens up to the end portion of the extruder, i.e. up to the point where the plastic film 5 exits from the extruder 1. In the nozzle 6 of the extruder 1 the plastic 5a is thus all the time subjected to cross-direction orientation in addition to longitudinal orientation, which makes it considerably easier to orientate the plastic film in the cross-direction at a later processing stage.

Figure 7a is a side view of the plastic film 5. Before extrusion calcium carbonate particles 24 have been mixed into the plastic 5a. Instead of calcium carbonate particles 24 some other material may also be mixed into the plastic 5a. The material should be such that it causes the joint surface of the plastic molecules and the material mixed into the plastic 5a to tear when the plastic film 5 is stretched so that cavitation bubbles are formed where the joint surfaces are torn. Thus some oily substance, such as silicone oil or paraffin oil,

can be mixed into the plastic 5a.The particles mixed into the plastic 5a may cause spot-like asymmetry e.g. in the electric field in the plastic 5a, whereas the oily substance mixed into the plastic does not substantially worsen the electric properties of the plastic. It is also possible to mix a substance having a melting point lower than the orientation temperature of the plastic 5a, such as paraffin, into the plastic, in which case the substance melts when the plastic 5a is orientated. The plastic 5a may be made e.g. from polypropylene PP, polymethylpentene TPX or cyclic olefin copolymer COC. The heat resistance of polymethylpentene and cyclic olefin copolymer are better than that of polypropylene, for example. Electric charges also remain in polymethylpentene and cyclic olefin copolymer better than in polypropylene at high temperatures. Processing of polymethylpentene and cyclic olefin copolymer is very difficult but by the method and apparatus of the invention a very thin and foamed plastic film 5 can be made of them. In the situation illustrated in Figure 7a the plastic film 5 has not been stretched yet.

Figures 7b and 7c illustrate the plastic film 5 after it has been stretched in the machine direction orientation device 12, in which case the plastic film 5 has been simultaneously subjected to the pressure of the pressurized gas. In that case gas has diffused in the cavitation bubbles and caused overpressure in them, as a result of which bubbles 25 containing gas have formed. In the situation illustrated in Figures 7b and 7c the plastic film 5 has been subjected only to machine direction stretching, and consequently the bubbles 25 are long, flat and narrow.

Figure 7d illustrates a situation in which the plastic film 5 has also been stretched in the cross-direction by means of the cross-direction orientation device 17. The gas that was overpressurized in the bubbles 25 in the situation illustrated in Figures 7b and 7c has released in the lateral direction in the cross-direction orientation device 17. Thus the bubbles 25 are now also wide. In addition, the bubbles 25 are flat, i.e. they are plate-shaped or disk-like. The bubbles 25 are relatively small, their diameter is at most about 100 micrometers and their height is typically less than one micrometer, at most about 10 micrometers. However, the method and apparatus provide very thin plastic films 5. The thickness of the plastic films 5 may be only 10 micrometers.

The plastic film 5 can be used for several purposes in a manner known per se. At least one surface of the plastic film 5 can be provided with an

electrically conductive coating, for instance, in which case the solution can be used e.g. as a microphone or loudspeaker in several acoustic applications, including sound attenuation. The plastic film 5 may also be permanently electrically charged.

The drawings and the related description are only intended to illustrate the inventive concept. The details of the invention may vary within the scope of the claims. Thus the orientation directions of the plastic film 5 and the order of orientations in different directions may vary. According to the invention, the simplest way to make a plastic film is to orientate the plastic film in the machine direction first and thereafter in the direction transverse to the machine direction.

CLAIMS

1. A method for producing a plastic film, the method comprising extruding a plastic film (5) and orientating it, **characterized** in that before extrusion material is mixed into the plastic (5a) of the plastic film (5) , cavitation bubbles are formed in the plastic (5) film to be stretched due to the influence of the material, after extrusion the plastic film (5) is orientated by stretching, and simultaneously with orientation pressurized gas is arranged to act on the plastic film (5) so that the gas diffuses in the cavitation bubbles, and thus bubbles (25) containing gas are formed in the plastic film (5).

2. A method according to claim 1, **characterized** in that gas is arranged to act on the plastic film (5) at the first orientation stage and thereafter the plastic film (5) is subjected to a second orientation which is substantially perpendicular to the first orientation so that the bubbles (25) containing gas expand due to the influence of the second orientation and the gas.

3. A method according to claim 2, **characterized** in that at the first orientation stage the plastic film (5) is orientated in the machine direction and at the second orientation stage the plastic film (5) is orientated in the direction substantially transverse to the machine direction.

4. A method according to any one of the preceding claims, **characterized** in that the pressure of the gas acting on the plastic film (5) is over 3 bars.

5. A method according to any one of the preceding claims, **characterized** in that before extrusion an oily substance or a substance having a melting point lower than the orientation temperature of the plastic (5a) is mixed into the plastic (5a).

6. An apparatus for making a plastic film, the apparatus comprising an extruder (1) and at least one orientation device (12, 17) for orientating the extruded film (5), **characterized** in that the apparatus comprises gas supply means (15, 16) arranged in at least one orientation device (12, 17) for feeding pressurized gas into the plastic film (5) simultaneously with orientation by stretching so that the fed gas diffuses in the cavitation bubbles that are formed in the plastic film (5) during stretching, and thus bubbles (25) containing gas are formed in the plastic film.

7. An apparatus according to claim 6, **characterized** in that the gas supply means (15, 16) are arranged in the first orientation device (12) and that the apparatus comprises a second orientation device (17) after the first orientation device (12) in the direction of the plastic film (5), the second orientation device (17) being arranged to orientate the plastic film (5) in the direction substantially transverse to the orientation direction of the first orientation device (12) so that the bubbles (25) containing gas expand due to the influence of the second orientation device (17) and the gas.

8. An apparatus according to claim 7, **characterized** in that the first orientation device (12) is arranged to orientate the plastic film (5) in the machine direction and the second orientation device (17) is arranged to orientate the plastic film (5) in the direction substantially transverse to the machine direction.

9. An apparatus according to any one of claims 6 to 8, **characterized** in that the gas supply means (15, 16) comprise a discharge chamber (15), in which case at least one orientation device (12, 17) is arranged inside the discharge chamber (15) so that the pressure of the gas in the discharge chamber (15) acts on both sides of the plastic film (5) simultaneously with the orientation effect of the orientation device (12, 17).

10. An apparatus according to any one of claims 6 to 9, **characterized** in that the extruder (1) comprises a nozzle (6) which is arranged to widen up to the end portion of the extruder (1).

11. An apparatus according to any one of claims 6 to 9, **characterized** in that the apparatus comprises a cross-direction orientation device (17), which comprises two orientation wheels (18) and endless orientation bands (19) which are arranged against the wheels and move around band guide rolls (20), both edges of the plastic film (5) to be orientated being arranged between the orientation wheel (18) and the orientation band (19) and the orientation wheels (18) and the orientation bands (19) being arranged so that in the direction of the plastic film (5) they are further away from one another at the end than at the beginning, in which case the cross-direction orientation device (17) stretches the plastic film (5) in the cross-direction.

12. An apparatus according to claim 11, **characterized** in that the apparatus comprises a curved support plate (21), which is arranged between the orientation wheels (18) to support the plastic film (5).

13. An apparatus according to claim 12, **characterized** in that the support plate (21) is provided with gaps (21a) and heated gas is arranged to flow through the gaps to heat the sliding surface of the support plate (21) and plastic film (5).

14. A plastic film, which comprises bubbles (25) with the maximum diameter of about 100 micrometers and the maximum height of about 10 micrometers, **characterized** in that material is mixed into the plastic (5a) of the plastic film (5), cavitation bubbles are formed in the stretched plastic film due to the influence of the material and the plastic film is subjected to stretching and to pressure of pressurized gas simultaneously with stretching so that the bubbles (25) contain said gas, the foaming degree of the plastic film (5) being over 70%.

15. A plastic film according to claim 14, **characterized** in that an oily substance or a substance having a melting point lower than the orientation temperature of the plastic (5a) is mixed into the plastic (5a) to provide the cavitation bubbles that are formed during stretching.

16. A plastic film according to claim 14 or 15, **characterized** in that the plastic film is made of polymethylpentene (TPX).

17. A plastic film according to claim 14 or 15, **characterized** in that the plastic film (5) is made of cyclic olefin copolymer (COC).

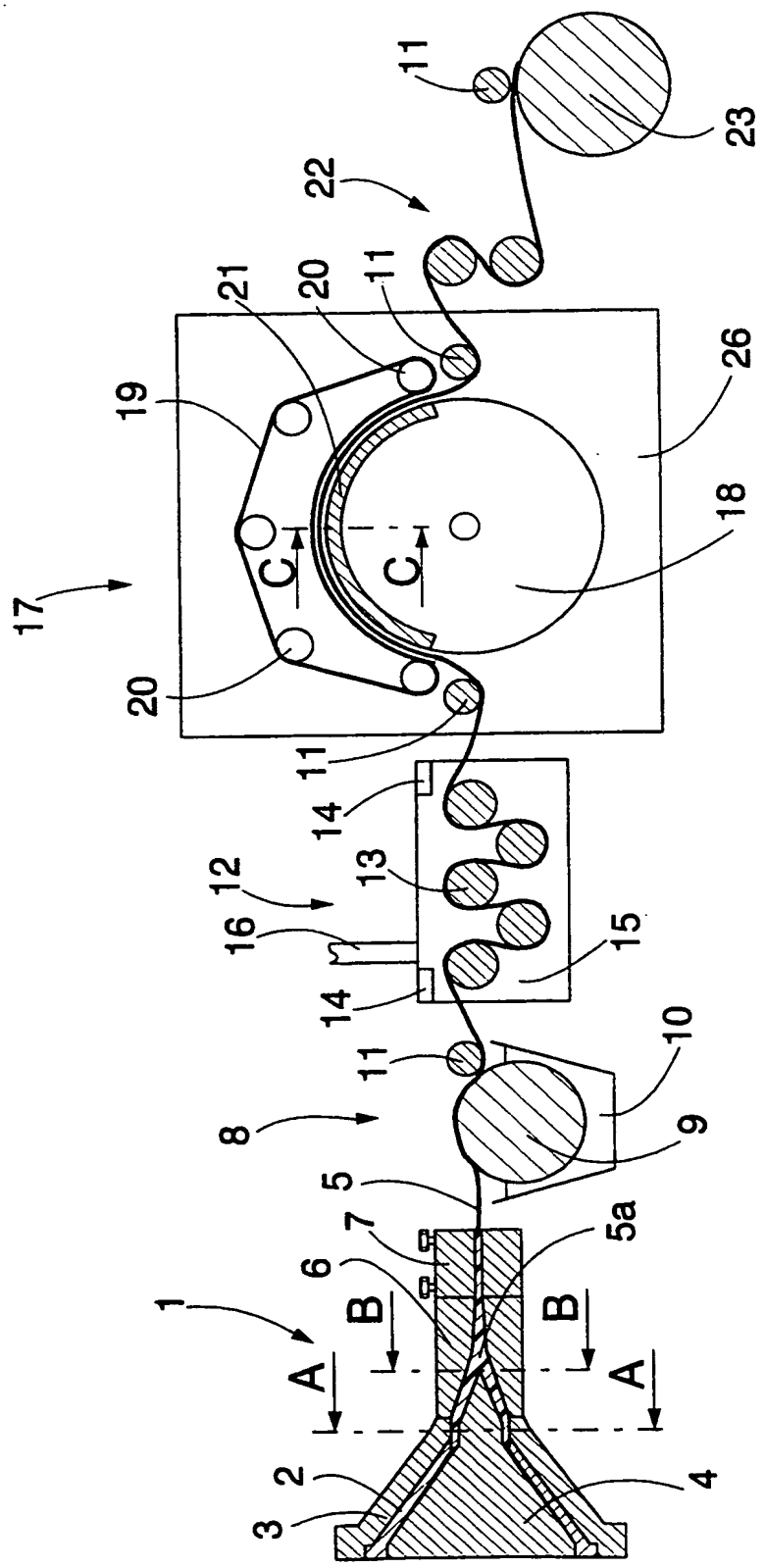

11
23
22
21
20
11
26
19
18
C
C
17
20
11
14
12
13
16
15
14
11
10
8
9
5
7
5a
6
1
B
B
A
A
2
4
3

FIG. 1

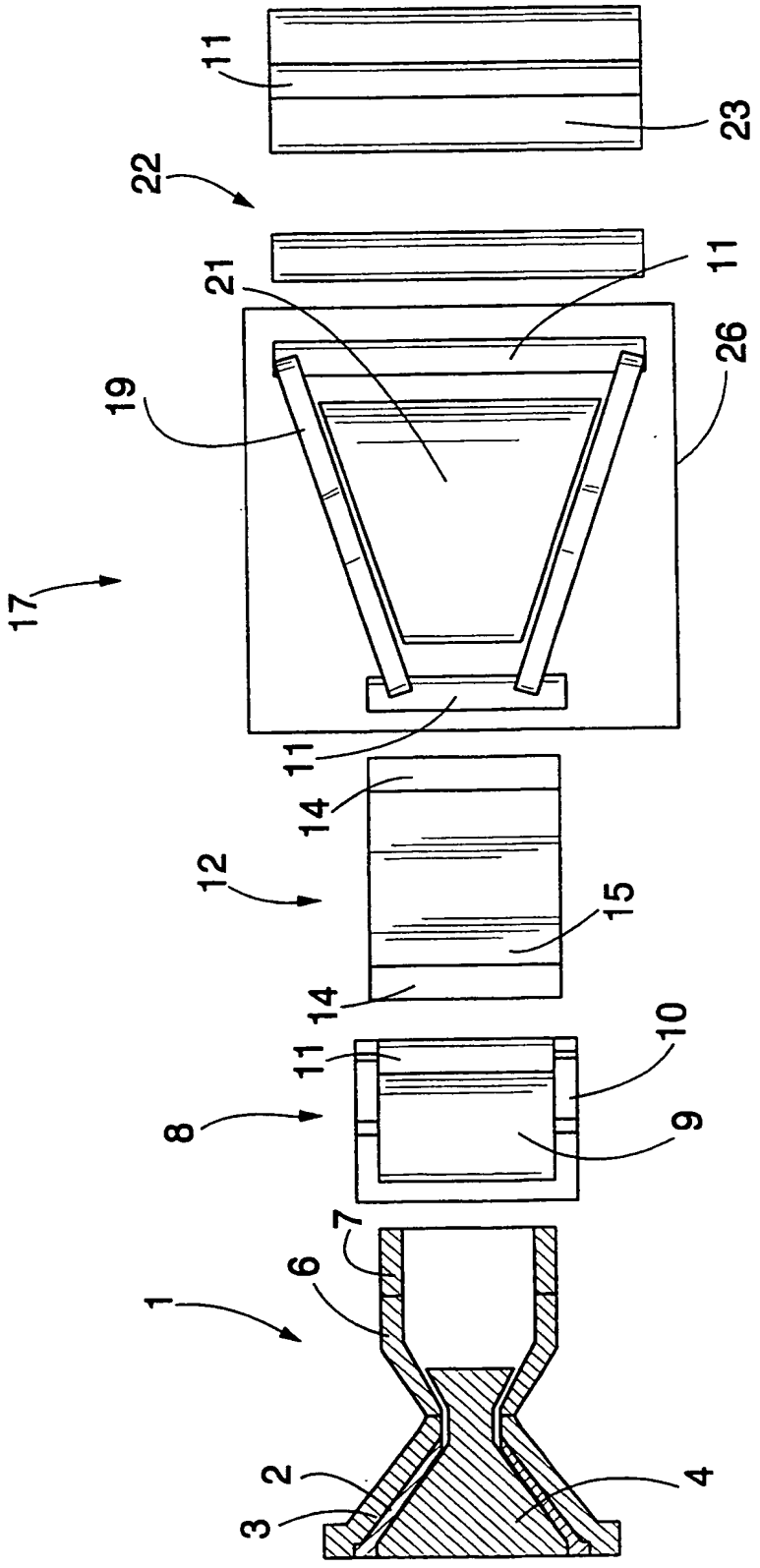



FIG. 2

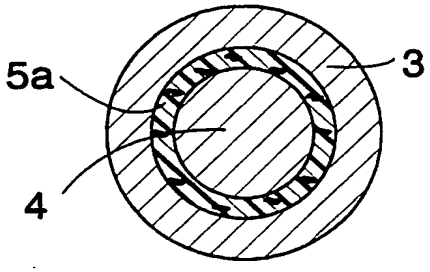



FIG. 3

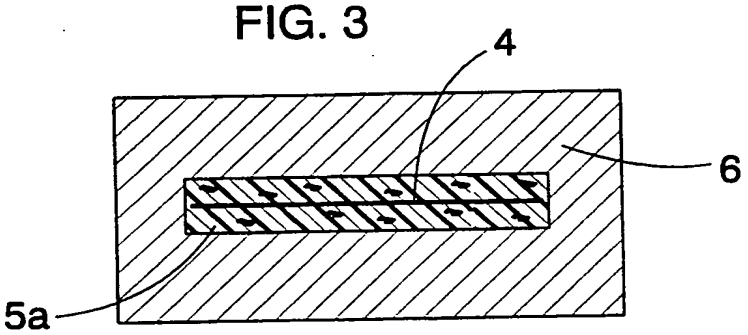



FIG. 4

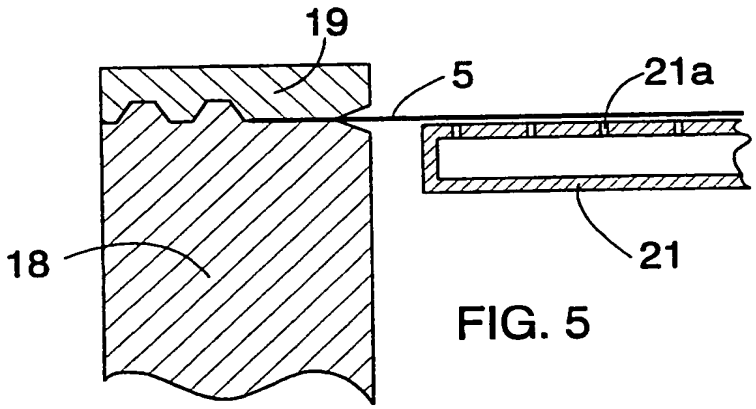



FIG. 5

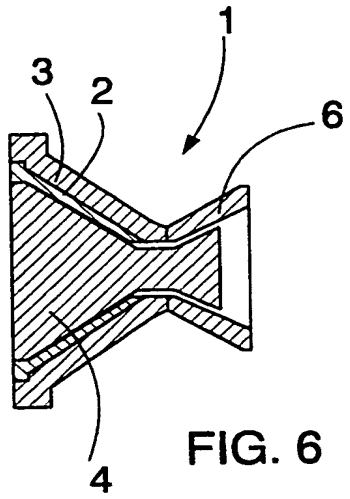



FIG. 6

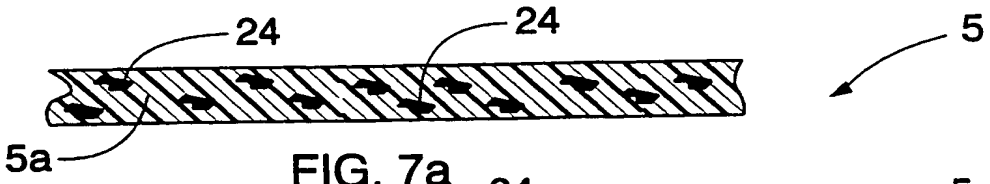



FIG. 7a

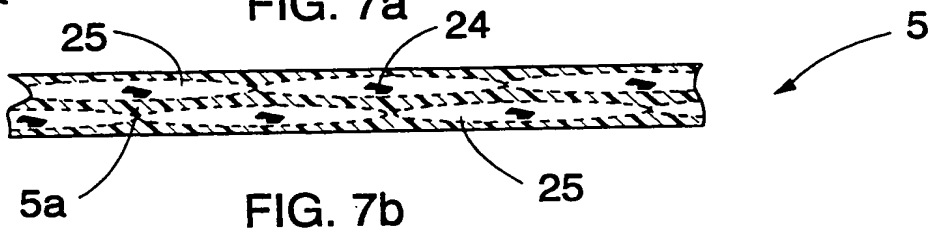



FIG. 7b

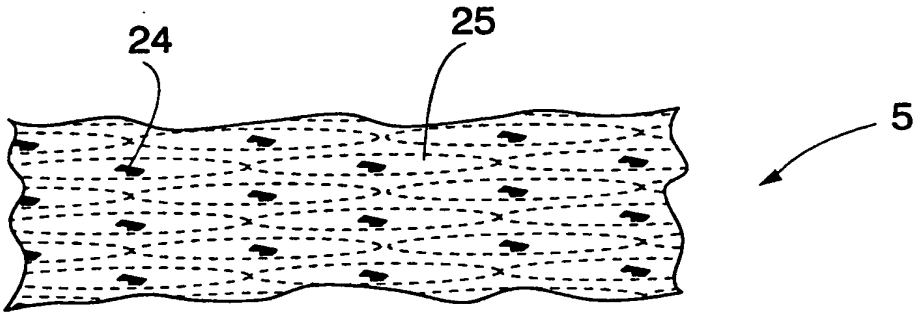



FIG. 7c

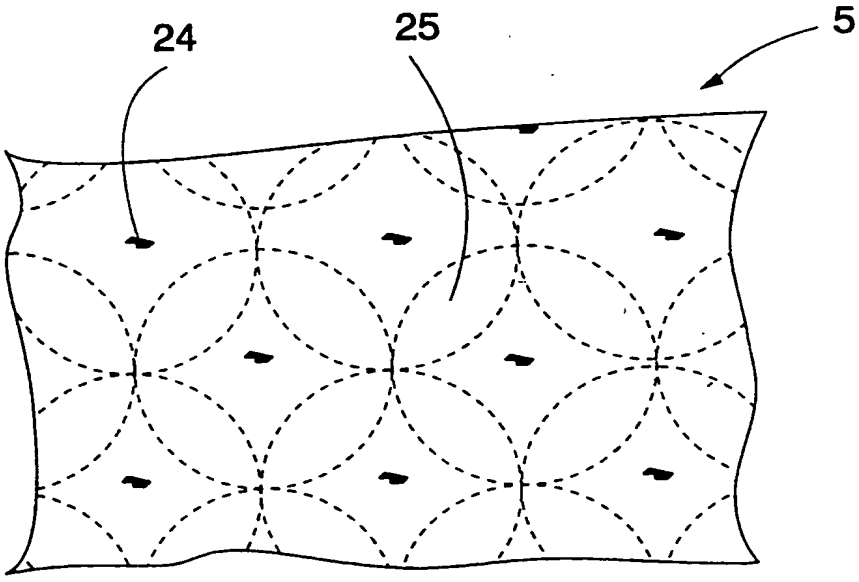



FIG. 7d

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00277

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B29C 55/02, B29C 55/14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 5188777 A (BURDETTE L. JOESTEN ET AL), 23 February 1993 (23.02.93), column 4, line 3 - line 14 -- | 1-17 |
| A | DE 3513526 A1 (HOECHST AG), 16 October 1986 (16.10.86), page 6, line 20 - line 24; page 7, line 19 - page 8, line 9 -- | 1-17 |
| A | GB 1384556 A (MITSUBISHI PETROCHEMICAL COMPANY LIMITED), 19 February 1975 (19.02.75), page 2, line 63 - line 90; page 4, line 25 - line 41, figures 2-4 -- -------- | 1-17 |

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 9 August 1999 | 11 -08- 1999 |
| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Authorized officer<br>Maria Börlin/ELY<br>Telephone No. +46 8 782 25 00 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

01/07/99

International application No.
PCT/FI 99/00277

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 5188777 A | 23/02/93 | US 5134173 A | 28/07/92 |
| DE 3513526 A1 | 16/10/86 | NONE | |
| GB 1384556 A | 19/02/75 | NONE | |